

IMAPS-Benelux Spring Event 2014

Technology development for a flexible, low-cost backplane for lighting applications

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PHILIPS

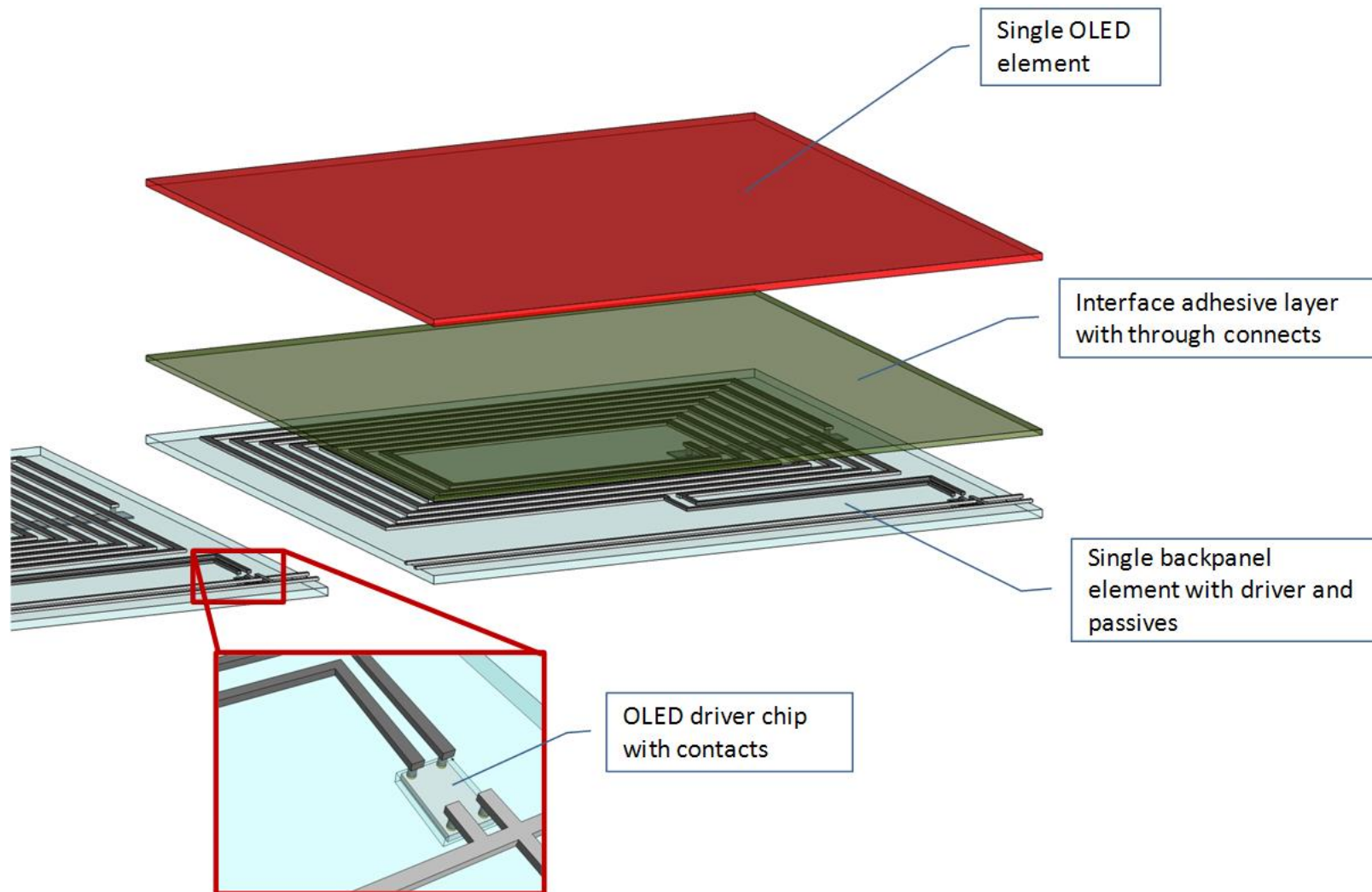
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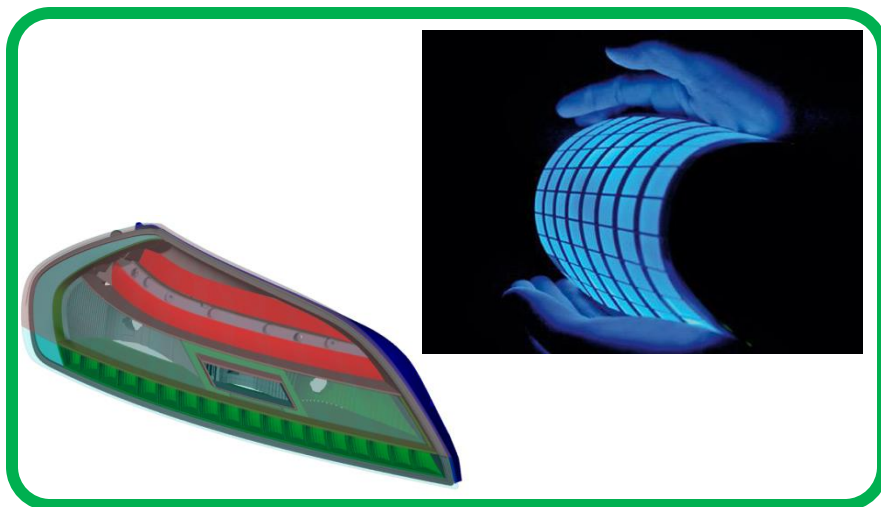
Fundi€o

- IMOLA concept
- Application requirements
- Technology specifications
- Process flow
- Technology developments
- Technologies for increased flexibility
- Conclusions

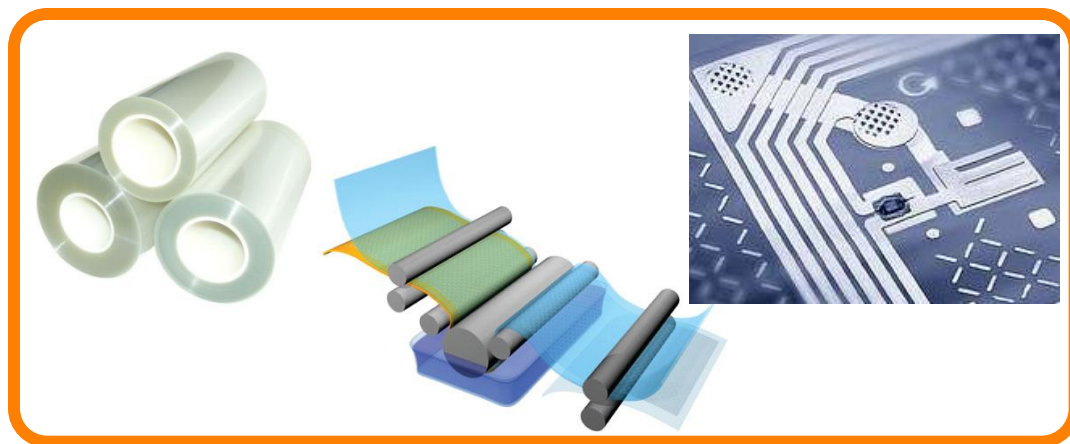
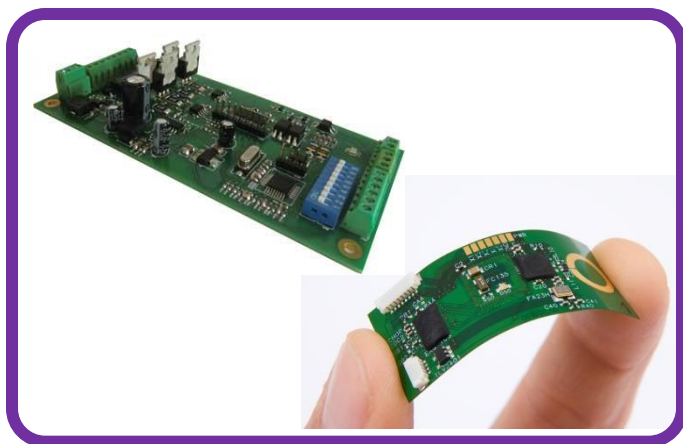
IMOLA concept



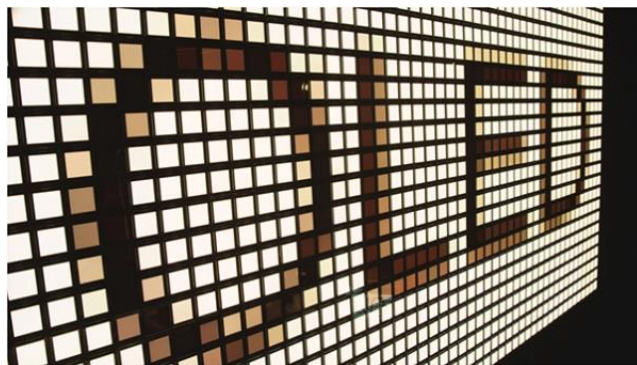
Application requirements



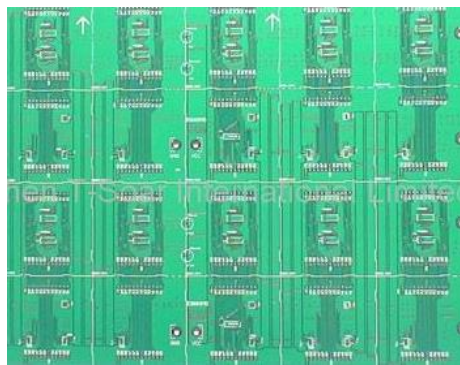
Interactive, modular, flexible, large-area, OLED-based lighting system on low-cost foil with built-in intelligent light management



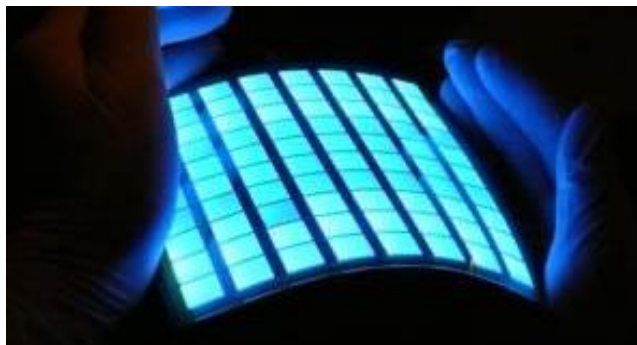
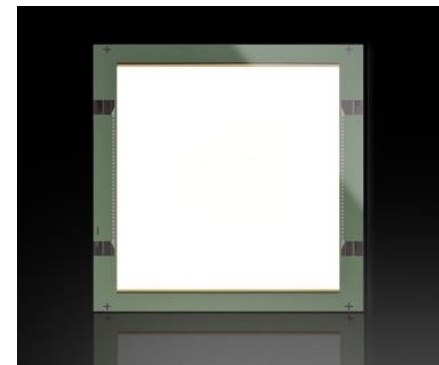
Technology specifications



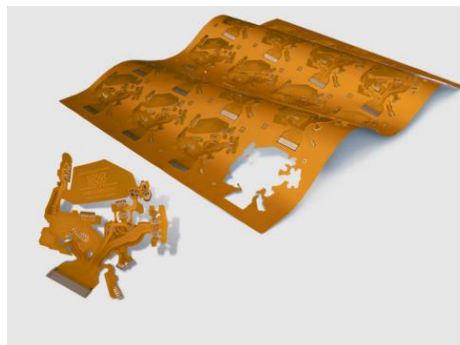
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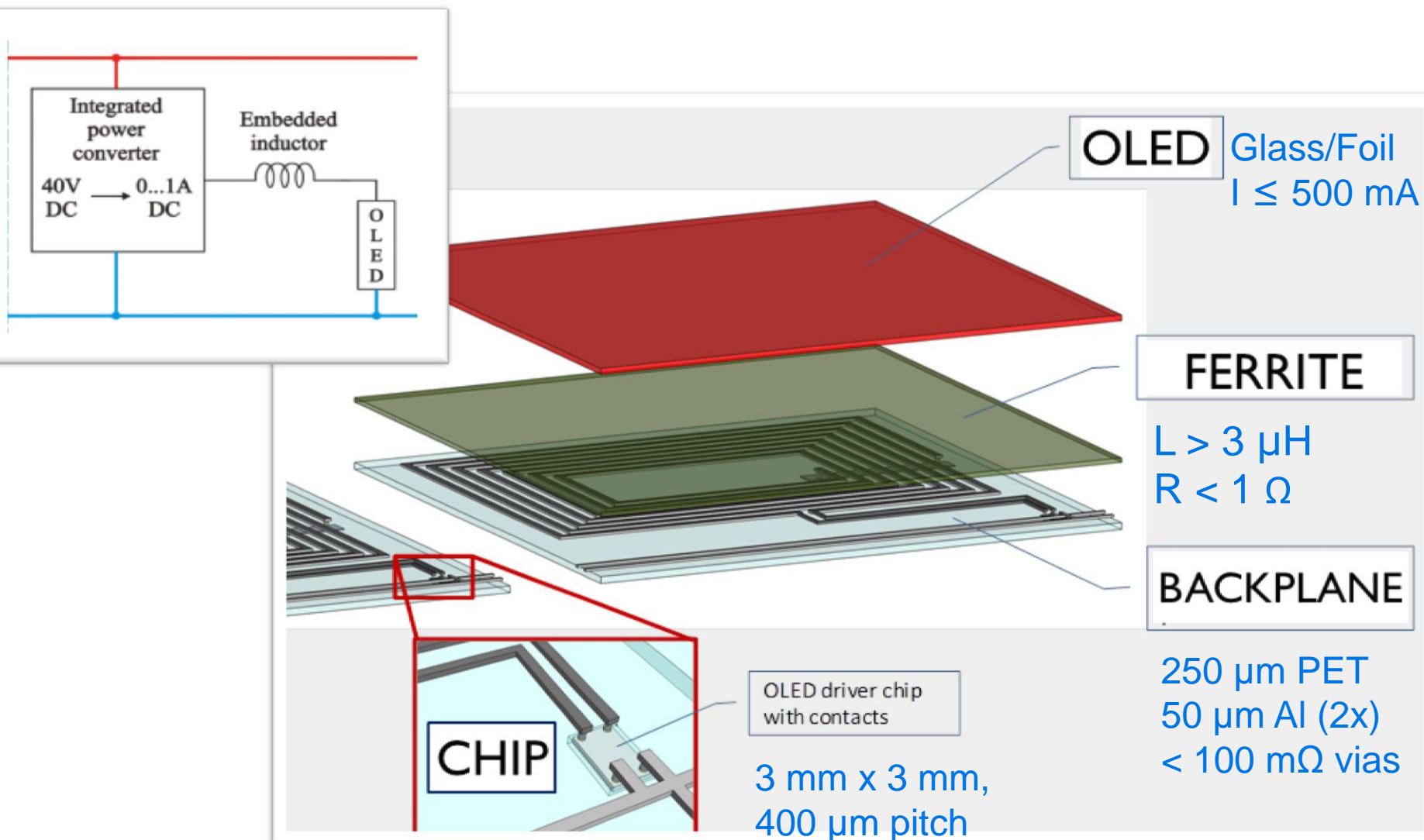
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PI: € 20 per m²
Cu: € 6 per kg

PET: € 2.0 per m²
Al: € 1.4 per kg

Technology specifications



Process flow

1. Al-PET-Al laminate



2. Structuring Al



3. Via drilling



4. Via filling



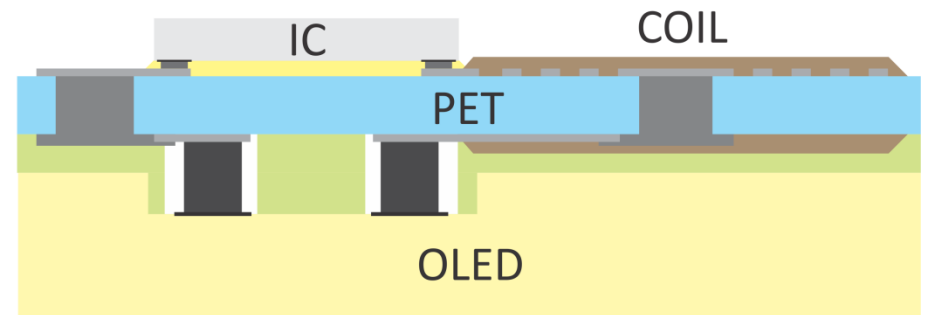
5. Ferrite printing



6. Chip mounting



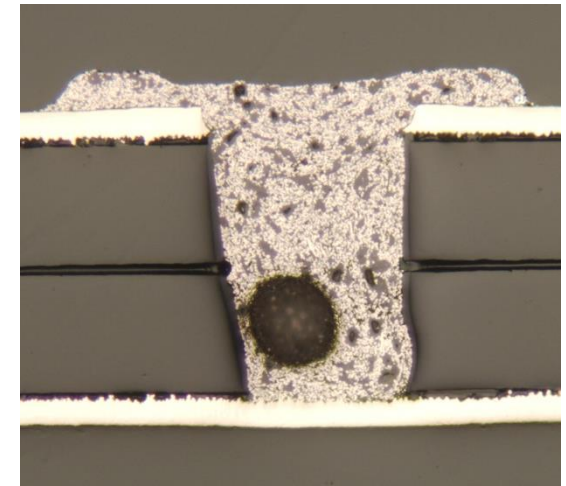
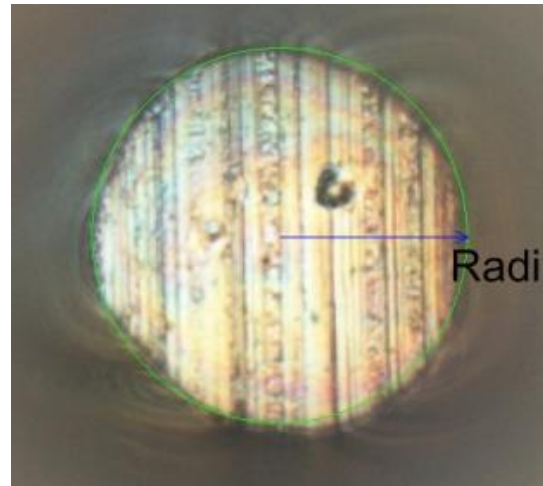
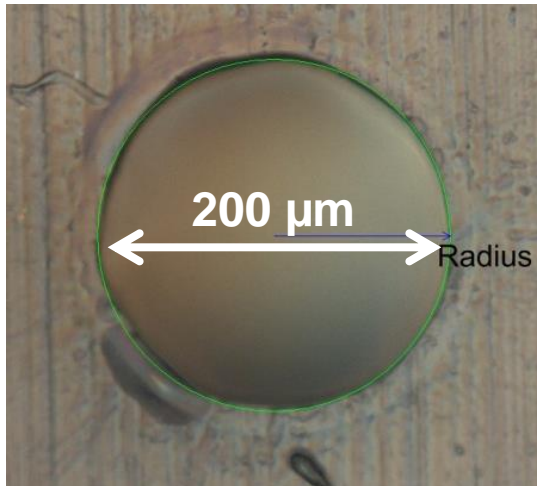
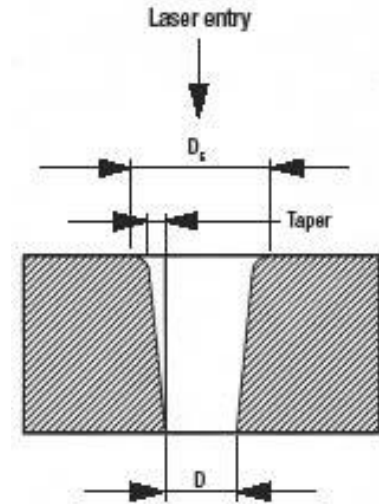
7. OLED mounting



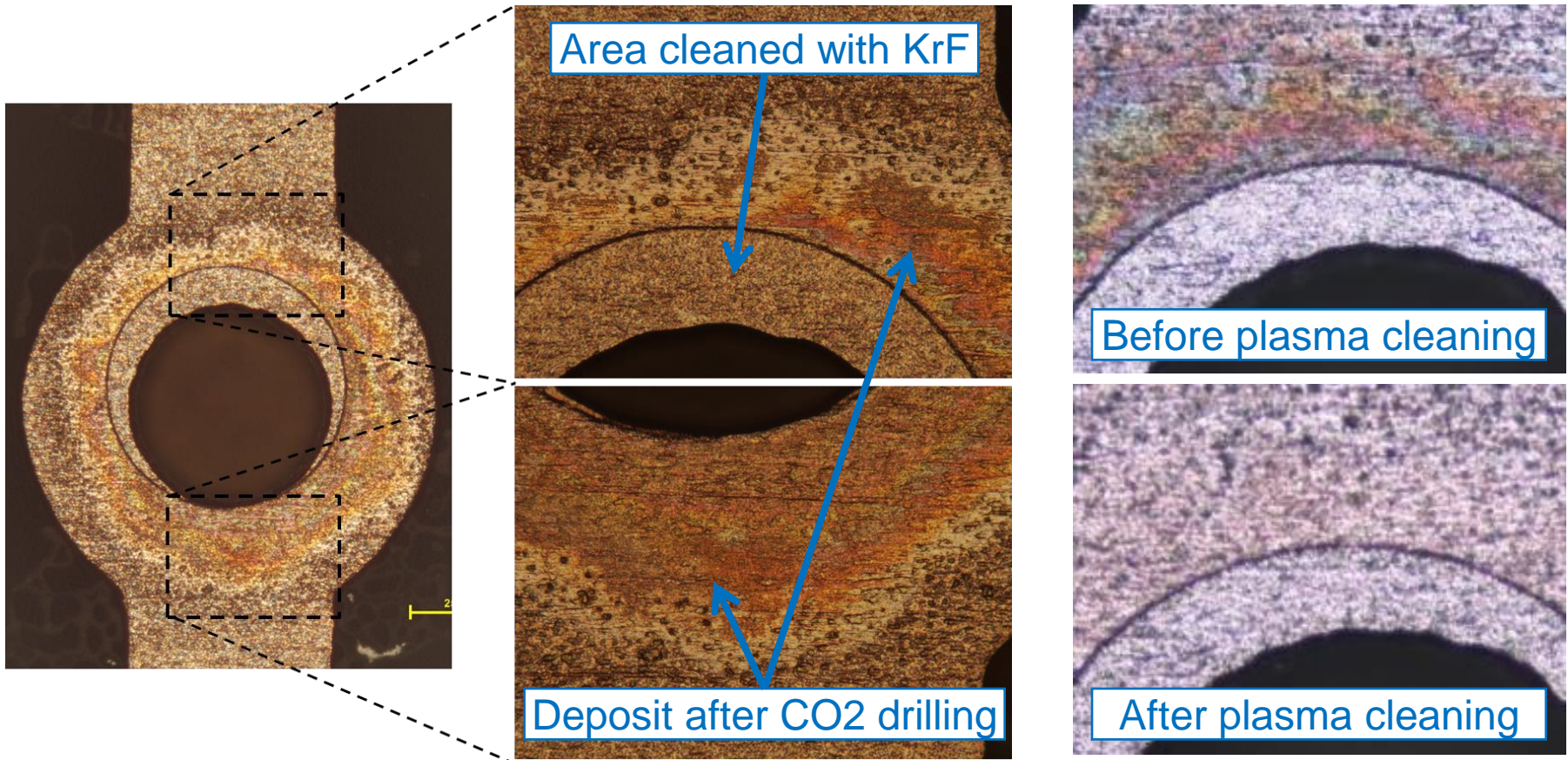
Via drilling

■ Via drilling by laser

- Aluminum is used as hard mask for CO₂ laser drilling
- Additional UV laser desmear after CO₂ drilling
- Optimize via tapering for filling process
- Design compensation to match foil deformation



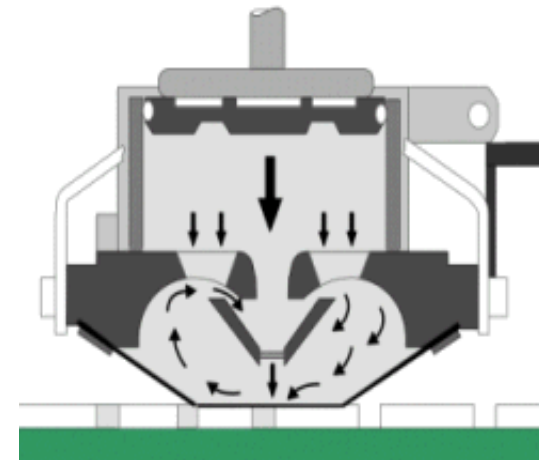
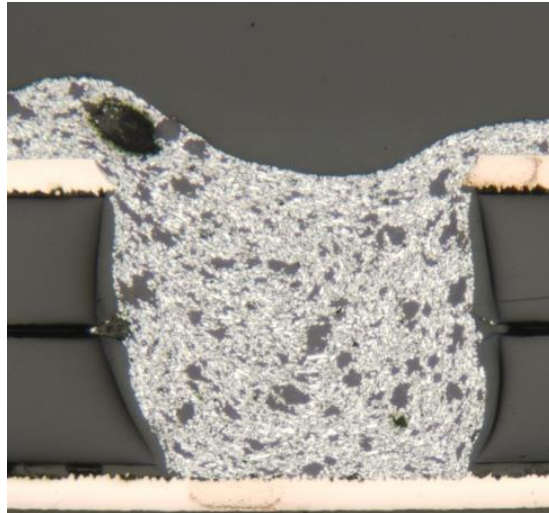
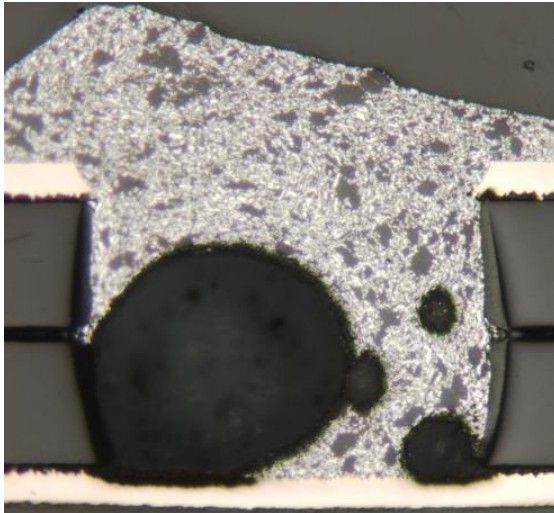
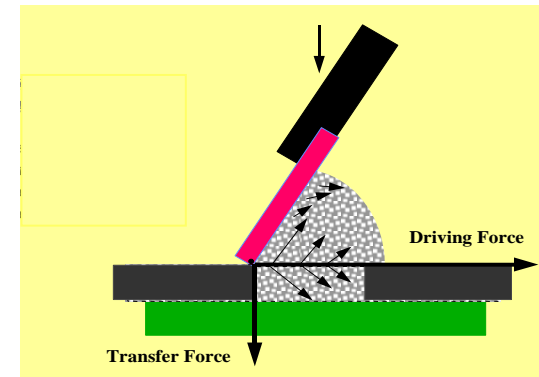
- Desmear after CO₂ drilling
 - Pulsed KrF laser desmear
 - Oxygen plasma desmear



■ Via filling by stencil printing

- Enclosed print head (Dek ProFlow) for high-aspect ratio via filling
- Design of experiment on Cu-PET-Cu with CE 3103 WLV
 - Minimize entrapped air bubbles
 - Improve contact between ICA and copper
- Results
 - Single print stroke with medium speed
 - High ProFlow head pressure

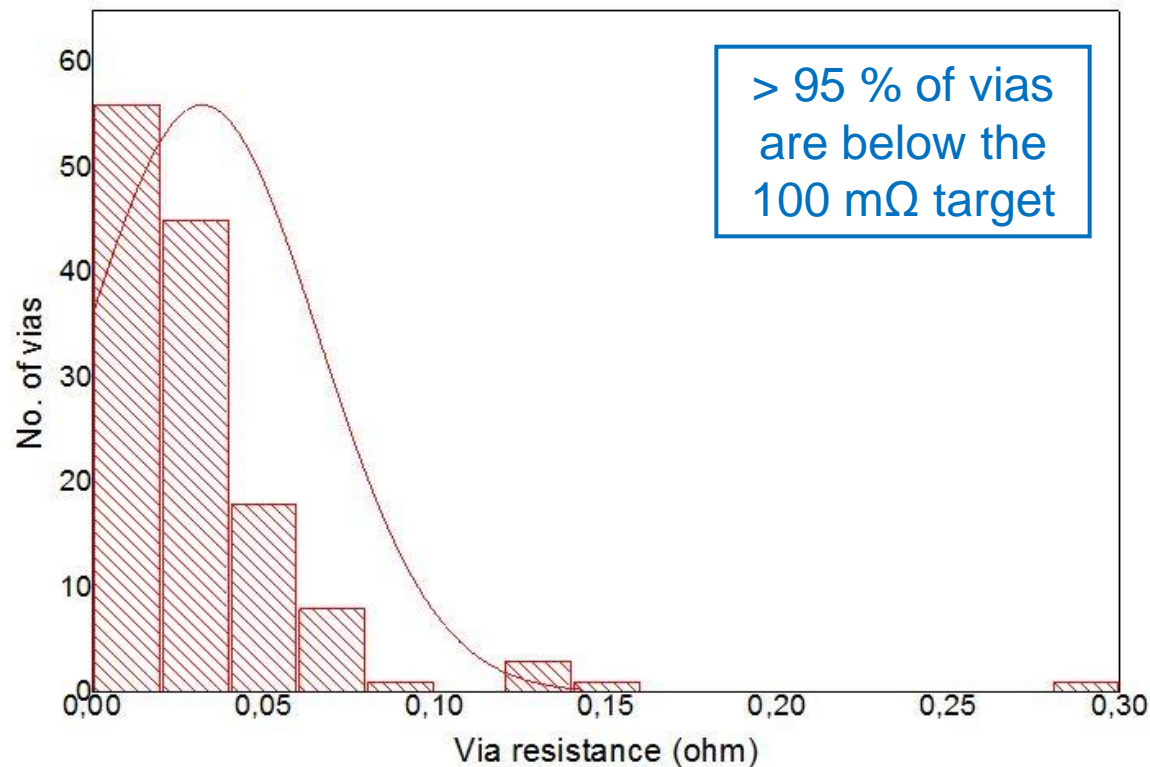
Squeegee



ProFlow

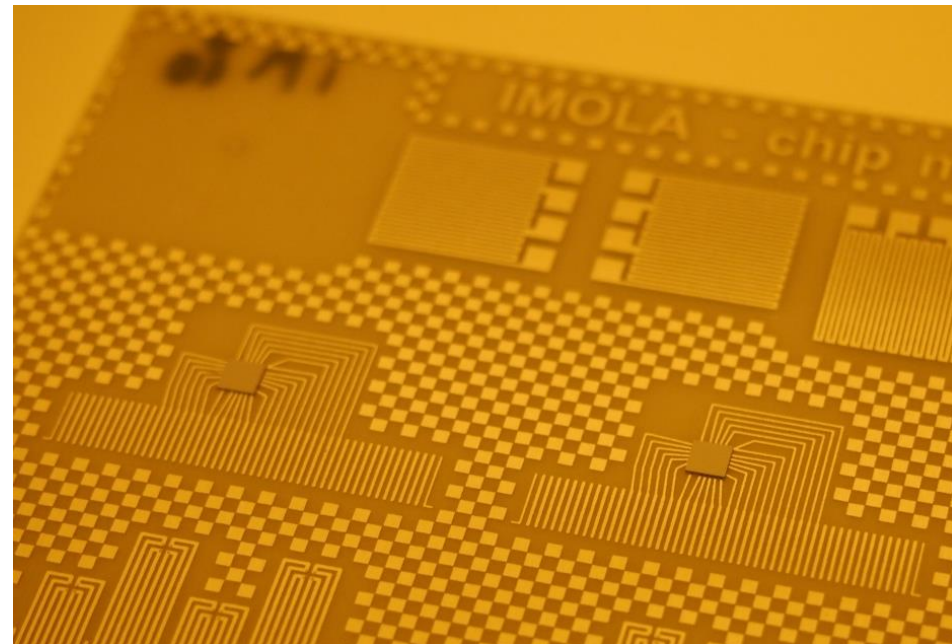
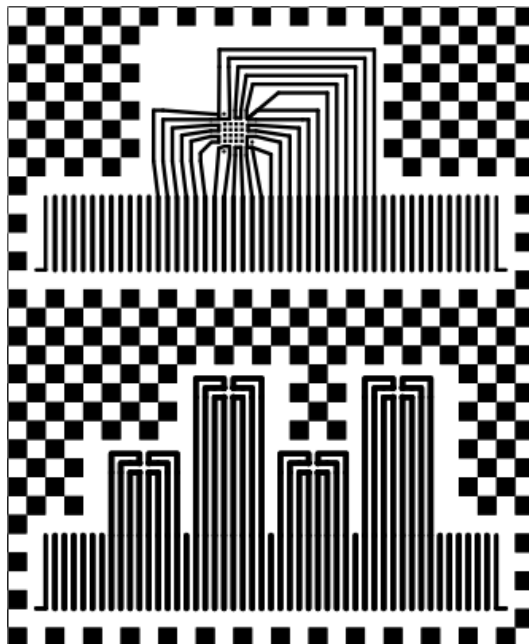
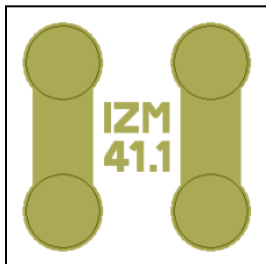
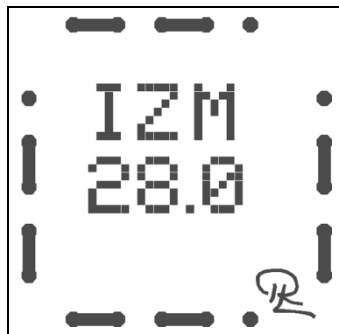
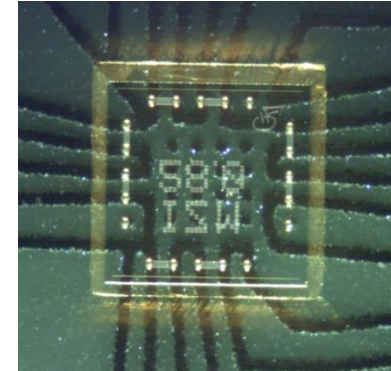
■ Via filling by stencil printing

- Histogram of via resistance (Ω) for 135 vias (9 samples over two printing runs) with an aspect ratio of 4:5 (350 μm depth and 450 μm diameter)



■ Flip-chip mounting using stencil printed ICA bumps

- Two test chips
 - IZM28 (2.5 mm x 2.5 mm, 300 μ m pitch, 20 contacts)
 - IZM41 (0.9 mm x 0.9 mm, 500 μ m pitch, 4 contacts)
- Bonding parameters: 3 min @ 180 °C and 0.5 N pressure
- Small contact pads on IZM28 incompatible with ICA printing



■ Flip-chip mounting using stencil printed ICA bumps

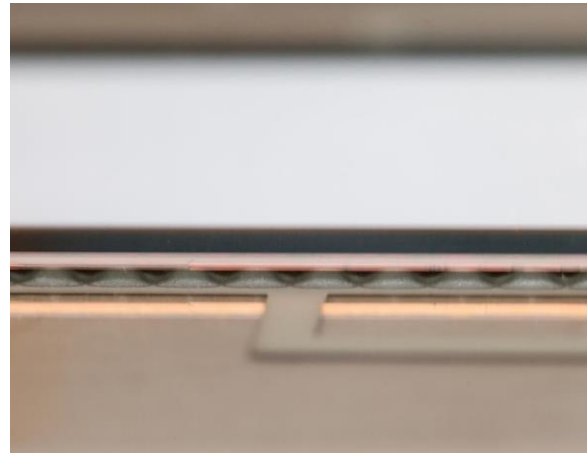
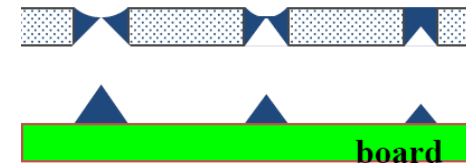
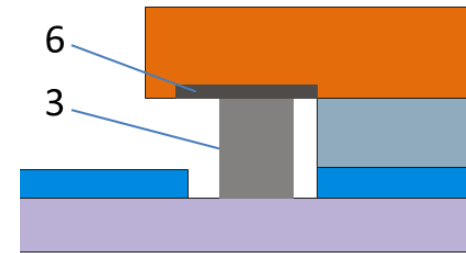
- Low and reproducible resistance on PET-Cu
- Large variation in contact resistance on PET-Al

C O P P E R	1		2		3		4	
	A	B	A	B	A	B	A	B
	62,2	67,4	61,5	61,8	71,5	59,7	67,4	59,2
	62,2	67,4	61,5	61,8	71,5	59,7	67,5	59,2
	57,5	63,9	61,1	55,9	57,5	60,2	61,1	58,5
	57,5	63,9	61,1	55,9	57,5	60,2	61,1	58,5

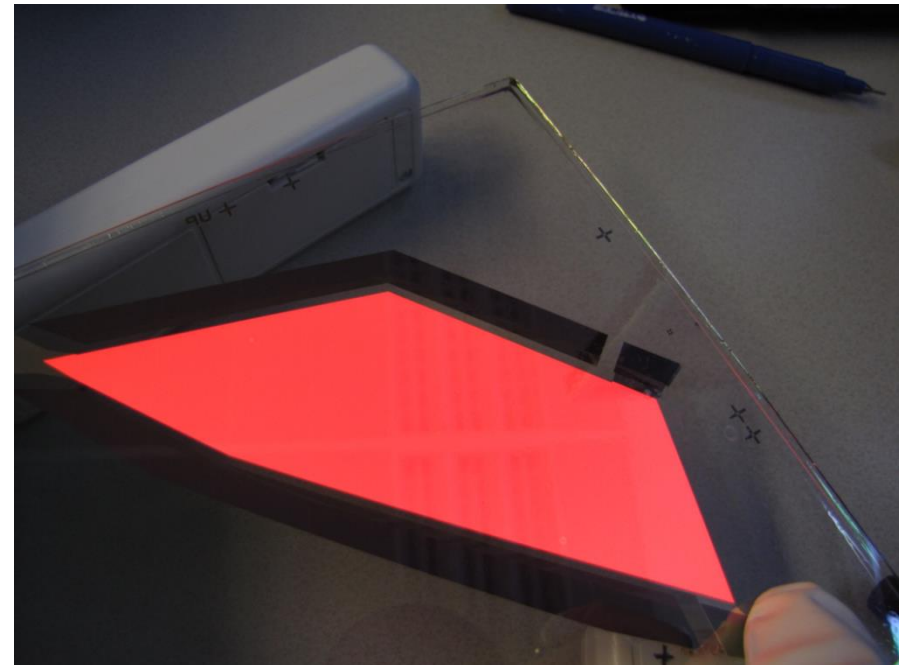
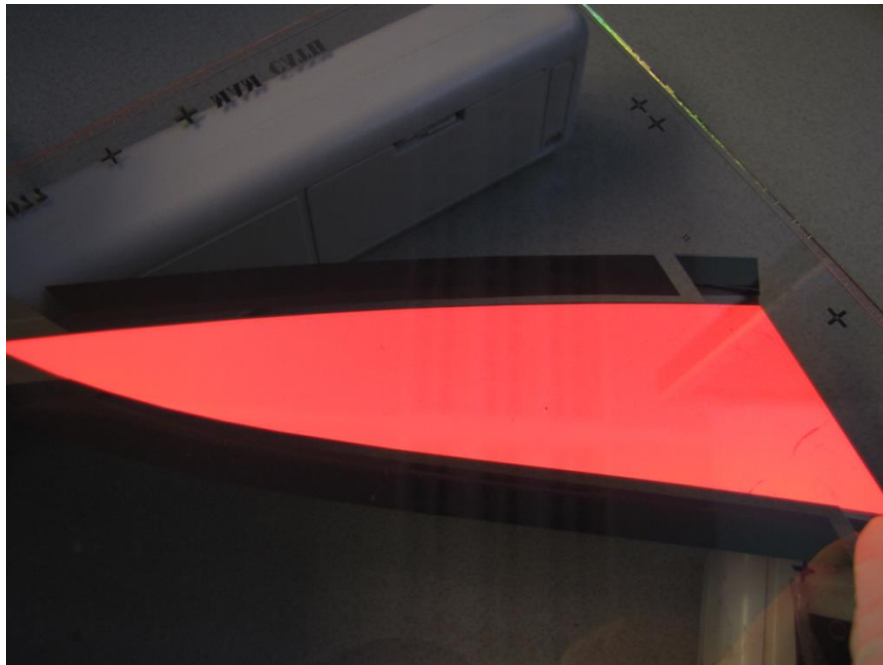
A L U M I N I U M	1		2		3		4	
	A	B	A	B	A	B	A	B
	295,7	5000	89,5	672,1	110,9	1214	1718	3706
	297,4	15700	89,6	675,6	111	1219	1759	3760
	12085	9856	97,7	332,9	145,5	503,4	808,1	782,3
	11900	10170	97,4	330,8	144,9	499,6	807,6	782,4
	188,9	784,6	1232	755,3	238,9	799,6	306,2	464,5
	190,3	791,5	1297	758	241,6	802,6	307,3	465,1
	279,6	1866	1002	15000	291,4	614	91,8	11065
	278,9	1866	1002	50000	289,4	611,7	91,8	10900

■ Structural film adhesive combined with printed ICA bumps

- Very high bumps required to bridge glass encapsulation
- Even distribution of OLED contacts for optical uniformity
- Pre-structured film adhesive applied to backplane before printing
- Dek PumpPrint technology for printing >1.5 mm high bumps
- Optimized stencil design and print process make it possible to reliably print pyramidal dots with a 1:2 aspect ratio
- Higher aspect ratios are possible with optimized material

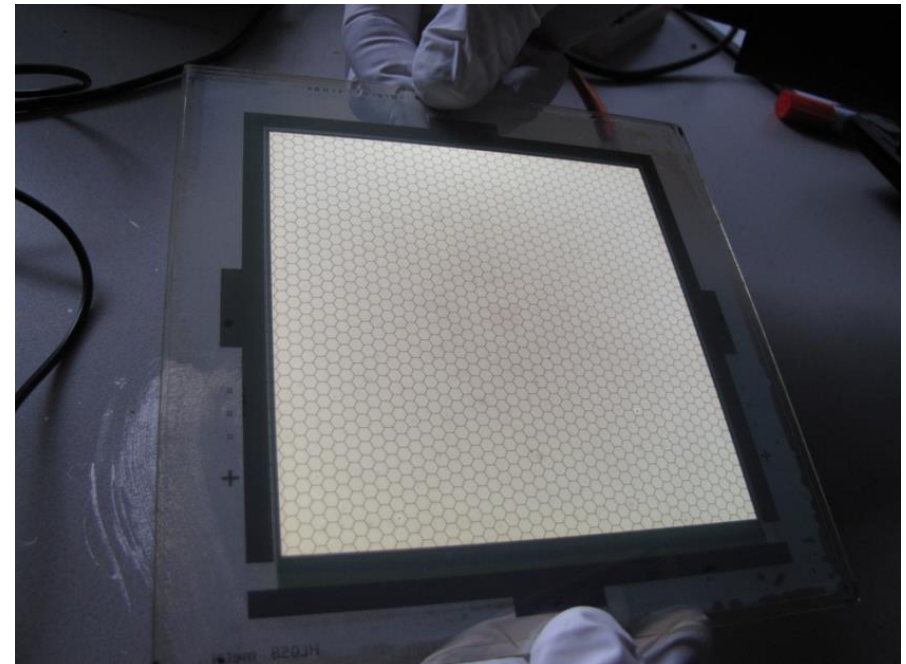
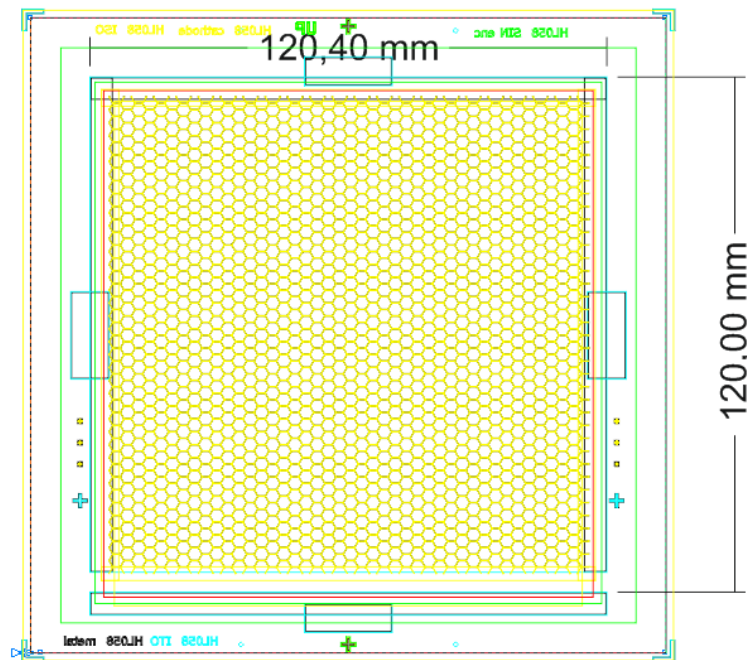
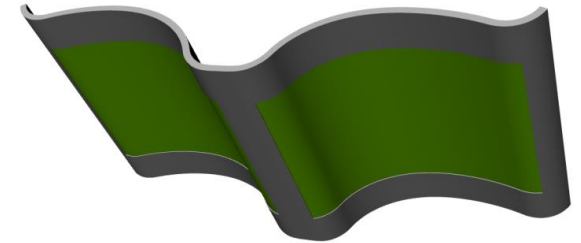


- Flexible OLED technology (Holst Centre)
 - Bottom emission type, fabricated on PEN foil
 - Efficiency of up to 47 lumens per watt (white light)
 - SiN-OCP-SiN barrier stacks (Holst Centre IP) on cathode and anode sides
 - Customized design for IMOLA applications



Increased flexibility - OLEDs

- Flexible OLED technology (Holst Centre)
 - Honeycomb shunt lines for uniform current distribution over large area (> 10 cm x 10 cm)

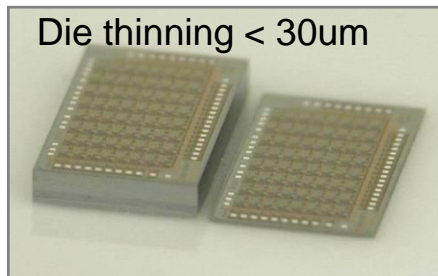


Once the backplane is flexible

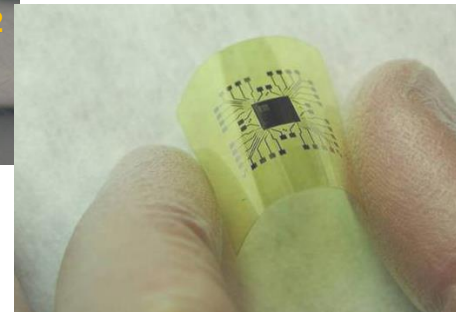
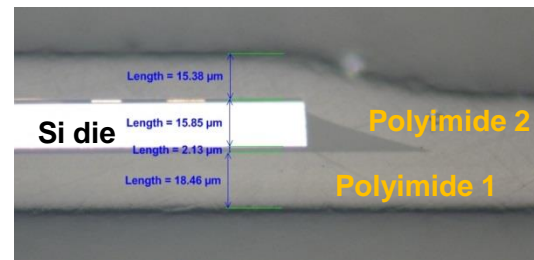
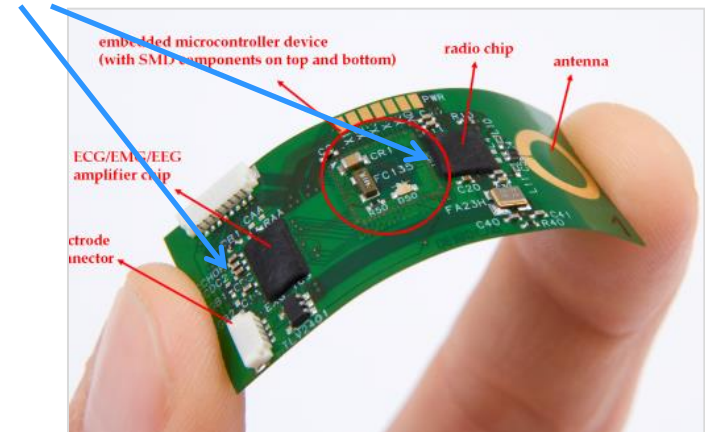
... flexibility is limited by the rigid components

A solution :

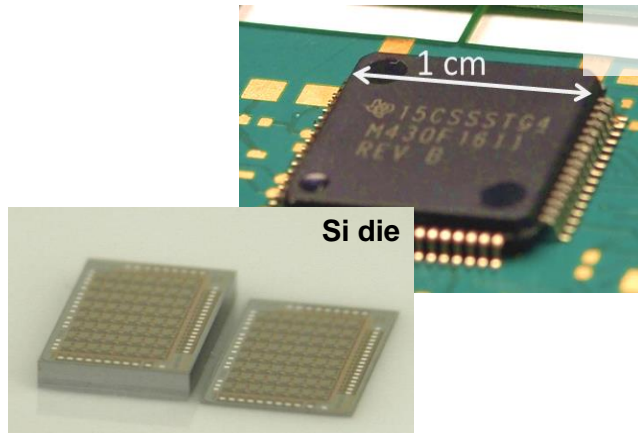
- Thin down chips, down to foil-thickness ($\pm 30 \mu\text{m}$, by grinding)



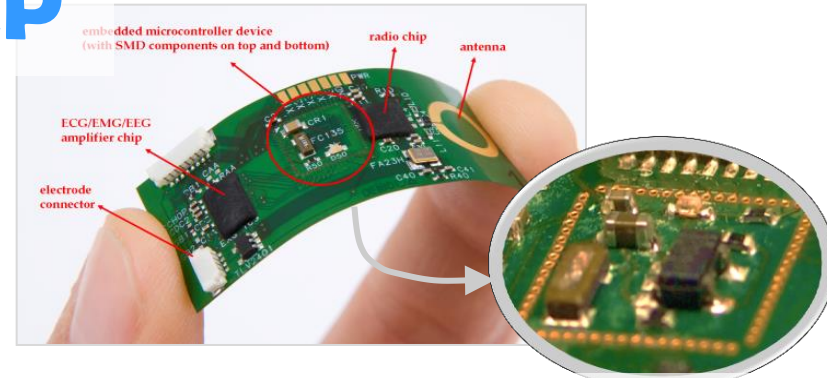
- Make a flexible interposer (e.g. based on polyimide)
- Embeddable in or on the flexible backplane



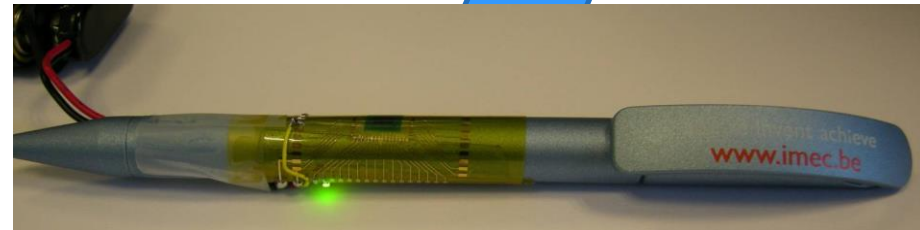
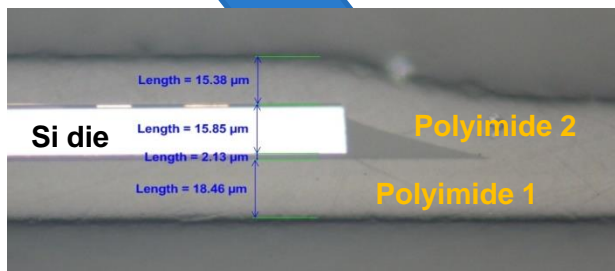
UTCP



- Small I/O pitch ($< 100\mu\text{m}$)
- 300-700 μm thickness

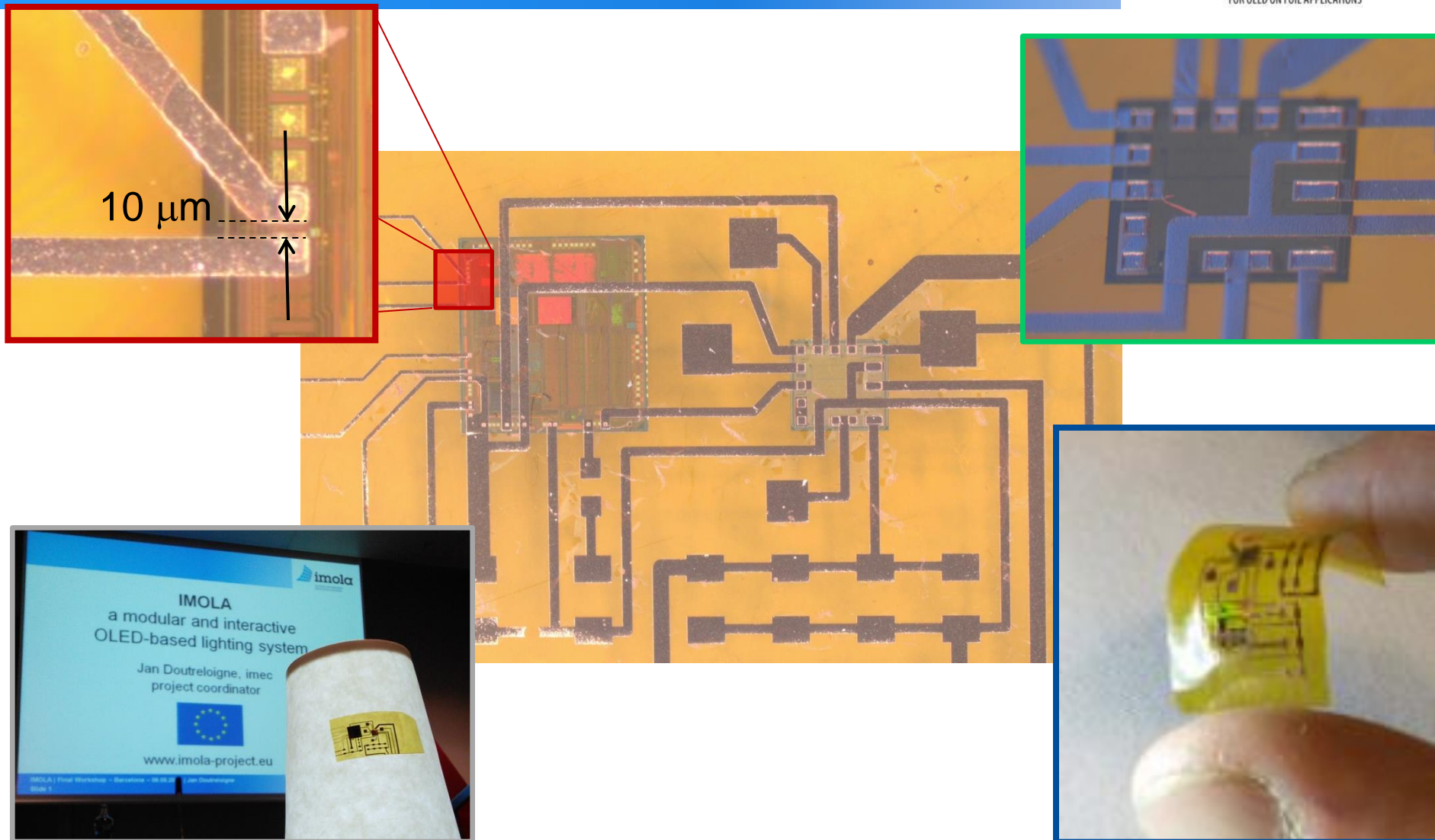


- PCB I/O pitch ($\sim 500\mu\text{m}$)
- Flexible



- UTCP interposer
- Flexible
- Known-Good-Package
- 60-80 μm thickness

Increased flexibility - UTCP

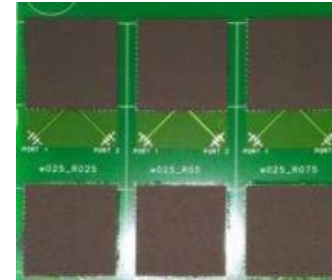


Conclusion

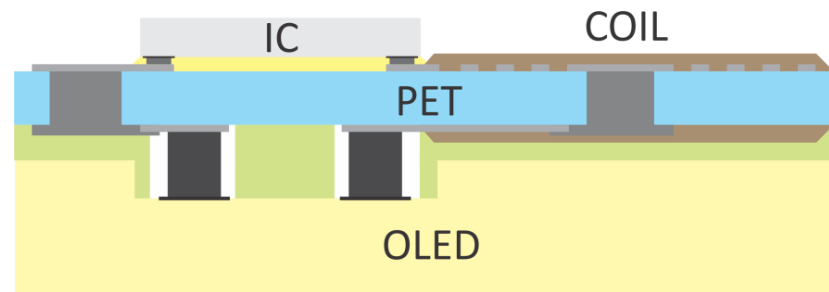
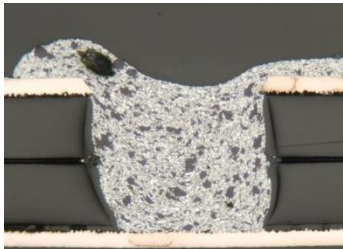
Al etching



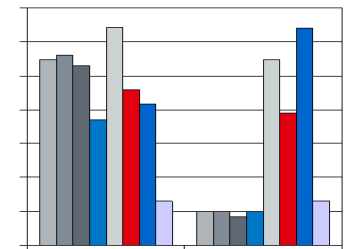
Ferrite printing



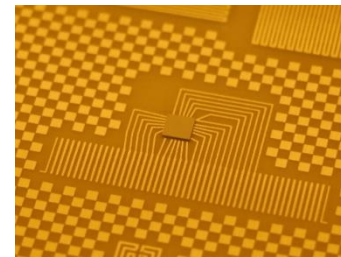
Via filling



Adhesive selection



OLED mounting



Chip mounting